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1 Description

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3 Device and method for monitoring a gas volume in a unit filled
4 with liquid

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6 The invention relates to a device for monitoring a gas volume
7 in a unit filled with a liquid, the unit being connected via an
8 inflow line to at least one expansion vessel and the device
9 including a buoyant body floating in the liquid. For the
10 purposes of the invention, the expansion vessel represents a
11 vessel which can receive the liquid expanding via the inflow
12 line of the unit, and represents a gas collecting container,
13 such as for example a Buchholz relay, which is arranged
14 upstream of a liquid expansion vessel. Furthermore, the
15 invention relates to a method for monitoring a gas volume in a
16 unit filled with liquid by means of a floating buoyant body in
17 an expansion vessel of the unit.

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19 In large transformers, adequate cooling of the units is
20 absolutely necessary on account of the great magnetic and
21 electrical losses that occur during operation and the
22 associated heating of the transformers. For this purpose, the
23 cores and windings of these transformers are mounted in a
24 liquid container, in particular an oil tank. The cooling liquid
25 located in the tank - usually a transformer oil - expands
26 during operation on account of the heating of the transformer,
27 the excess cooling liquid being collected in an expansion
28 vessel provided above the transformer. In addition to the heat-
29 induced expansion of the liquid, gases may be additionally
30 released from the cooling liquid or produced within the unit or
31 the connecting lines on account of the strong heating of the
32 cooling liquid

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1 or on account of chemical-physical processes occurring in the
2 transformer. Likewise, a leak within the unit or the connecting
3 lines may cause the ambient air to penetrate into this gastight
4 circuit and accumulate within the unit or in the expansion
5 vessels. Owing to their density, these gases collect in the
6 expansion vessels located above the transformer.

7
8 In their function as gas collecting containers, these expansion
9 vessels are usually also referred to as Buchholz relays. The
10 German industry standard DIN 42566 stipulates that, when
11 operating an oil-cooled transformer, a warning message must be
12 issued if a predetermined gas volume within the unit is
13 exceeded. Reaching the predetermined gas volume is in this case
14 detected within the Buchholz relay as a corresponding expansion
15 vessel and gas collecting container, which is arranged upstream
16 of an actual liquid expansion vessel. The liquid expansion
17 vessel serves exclusively for receiving the expanding liquid
18 and is therefore an open system, in contact with the ambient
19 air. If there is a liquid in the liquid expansion vessel and no
20 additional gases are formed within the unit, the expansion
21 vessel (Buchholz relay) is completely filled with liquid. On
22 the basis of the warning message detected in the expansion
23 vessel, a possible critical state of the transformer is
24 indicated and can be investigated by a thorough inspection of
25 the transformer.

26
27 In addition, DE 101 33 615 C1 discloses a device for detecting
28 undissolved gases in units filled with liquid,

29

1 in particular high-voltage units, the variation over time of
2 the production of gas in a Buchholz relay being determined by
3 means of the device. The measuring device proposed in DE 101 33
4 615 comprises a differential pressure measuring device, which
5 is connected via two liquid-filled lines to at least two
6 pressure measuring connections. The liquid-filled lines are in
7 this case connected on the one hand to the interior of the
8 Buchholz relay and on the other hand to an upwardly open
9 reference liquid column.

10
11 The object of the present invention is to detect quickly and
12 reliably the gas volume present in a unit filled with liquid.

13
14 The object is achieved by the device as claimed in claim 1 and
15 the method as claimed in claim 9.

16
17 For this purpose, it is provided according to the invention
18 that a floating buoyant body is connected to a shaft fixed in
19 the expansion vessel and is mounted rotatably with respect to
20 the shaft. For the purposes of the invention, the rotatable
21 mounting of the shaft comprises the articulation of the buoyant
22 body with respect to a rigid shaft, and also the rotation of
23 the shaft about three axes of rotation of the shaft with a
24 buoyant body fixedly connected to the shaft. The floating
25 buoyant body reproduces the vertical level of the surface of
26 the liquid within the expansion vessel, so that the additional
27 knowledge of the shape and size of the expansion vessel can be
28 used to conclude the gas volume located above the liquid.

29
30 A connecting element, in particular a rod of a small diameter
31 and low own weight, expediently connects
32

1 the shaft to the buoyant body kept at a distance from the
2 latter. The relative height of the shaft with respect to the
3 liquid surface and the length of the connection determine the
4 measuring range of the gas volume to be detected and the
5 accuracy of the gas detection.

6
7 A fixed-in-place force transducer advantageously detects the
8 torque on the connection at a predetermined length (a). If a
9 predetermined torque is exceeded by a torque measured in the
10 force transducer, a processing device generates a warning
11 message. With respect to the relative position of the shaft in
12 the expansion vessel, the predetermined torque is a measure of
13 the maximum gas volume to be detected within an expansion
14 vessel used as a Buchholz relay for issuing a warning message
15 and consequently conforms to the industry standard DIN 42566.

16
17 It is also advantageous that a number of buoyant bodies are
18 arranged at fixed vertical levels, respectively offset from one
19 another with respect to the shafts arranged parallel to one
20 another, the respective buoyant bodies being of different sizes
21 and/or densities. By providing buoyant bodies of different
22 densities at different vertical levels of individual shafts,
23 different gases can be detected and/or the accuracies of the
24 gas volume measurement by means of the determined gas volumes
25 of the different gas volume measurements can be calibrated.
26 However, for the detection of different gases, it is necessary
27 that the expansion vessel is subdivided into separate chambers
28 and only one gas can be respectively determined in each chamber
29 by a buoyant body located in the chamber.

30

1 Alternatively, a fixed-in-place angulometer detects the angle
2 between the connection of the buoyant body and a transverse
3 axis of the shaft. It is likewise possible by means of
4 determining an angle to use the knowledge of the size and shape
5 of the expansion vessel to determine a gas volume located above
6 the liquid. If a predetermined angle of the connection of the
7 floating body in relation to the horizontal is exceeded, a
8 processing device in the expansion vessel used as a Buchholz
9 relay generates a warning message and consequently likewise
10 conforms to the industry standard DIN 42566.

11
12 The buoyant body advantageously includes additional capacitive
13 and/or inductive and/or optical elements, a processing device
14 detecting the electromagnetic and/or electrical and/or optical
15 signals generated by them. The use of additional, alternative
16 volume-determining methods makes it possible for the gas
17 volumes that are respectively determined to be calibrated with
18 one another.

19
20 According to the invention, a method for monitoring a gas
21 volume in a unit filled with a liquid is provided, the unit
22 having an inflow line with at least one expansion vessel and a
23 buoyant body that floats in the liquid being located in the
24 expansion vessel and the buoyant body being connected in the
25 expansion vessel to a fixed shaft and mounted rotatably with
26 respect to the shaft, the rotating movement of the floating
27 body with respect to the shaft being determined. The shaft is
28 advantageously fixed at a fixed vertical level within the
29 expansion vessel on the basis of a maximum gas volume to be
30 detected in relation to the inner side of the upper covering of
31 the expansion vessel and the shaft is fixed at fixed vertical
32 levels by means of a fixing device, in particular in the form

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1 of recesses provided along a mount.

2
3 Since the gas volume to be detected always accumulates above
4 the liquid in the expansion vessel used as a Buchholz relay,
5 the gas volume to be detected can expediently be fixed with
6 respect to the inner side of the upper covering and
7 consequently the vertical level of the shaft to be fixed can be
8 determined.

9
10 Further advantageous measures are described in the remaining
11 subclaims; the invention is described in more detail on the
12 basis of exemplary embodiments and the following figures, in
13 which:

14
15 Figure 1 shows a schematic representation of the device
16 according to the invention;

17
18 Figure 2 shows a schematic representation of a gas detection
19 system with two devices according to the invention.

20
21 Figure 1 shows a schematic representation of the device
22 according to the invention as an expansion vessel 1a. The
23 expansion vessel 1a, arranged above a transformer (not
24 represented), is connected via a connecting line (not
25 represented) to an access opening 2. The expansion vessel 1a is
26 also connected via an outlet opening 3 to a downstream
27 expansion vessel 1b (not represented), it likewise being
28 possible for the downstream liquid expansion vessel to be
29 designed as an expansion vessel 1a with an outlet opening
30 present in the upper covering (10a). The downstream expansion
31 vessel 1b (not represented) thereby prevents an excessive rise
32 in pressure

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1 within the expansion vessel 1a when it is completely filled
2 with a liquid. Arranged within the expansion vessel 1a are two
3 buoyant bodies 5, 6, the buoyant bodies 5, 6 being mounted
4 rotatably in relation to the liquid surface of the liquid
5 located in the expansion vessel 1a by means of spaced-apart
6 connecting elements 4a, 4b. The upper buoyant body 5 is
7 connected to a shaft 11 at a fixed vertical level 9 and
8 rotatably mounted. The lower buoyant body 6 serves for
9 switching off the entire transformer unit if the liquid level
10 falls below a specific level, and consequently threatens
11 overheating of the transformer. The same applies to the gate
12 check 8, which in the case of a sudden rise in pressure - such
13 as for example in the case of an explosion within the
14 transformer - ensures immediate locking of the expansion vessel
15 1a. The upper buoyant body 5 is arranged within the expansion
16 vessel 1a in such a way that, in the case of gas formation in
17 the expansion vessel 1a, permanent detection of the gas volume
18 is allowed. This is ensured by the upper buoyant body 5 being
19 arranged at a predetermined distance from the inner side of the
20 upper covering 10a of the expansion vessel 1a and mounted
21 rotatably with respect to the relative level 9 that is fixed in
22 this way. As a result, the formation of a gas volume within the
23 expansion vessel 1a can be monitored permanently and
24 continuously up until a maximum predetermined gas volume is
25 reached, and a warning message can be issued by the system if
26 the maximum predetermined gas volume is exceeded. The density
27 and size of the buoyant bodies 5, 6 and the length of the
28 connecting elements 4a, 4b are determined in dependence on the
29 liquid used, and consequently on the basis of the maximum
30 possible torque caused by the buoyancy of the floating body 5
31 in relation to the shaft 11. The force transducer 7, connected
32 to the upper buoyant body 5 or the upper connecting element 4a,
33

1 permanently reproduces the moment of force or torque generated
2 by the buoyant body 5 and is consequently a measure of the gas
3 volume located in the expansion vessel 1a, which as a result
4 can be detected quickly and reliably.

5
6 Figure 2 shows a schematic representation of a unit 12 with two
7 expansion vessels 1a, 1b according to the invention. An inflow
8 line 13 is arranged on a liquid container 14, in particular a
9 high-voltage transformer unit, in the region of the cover of
10 the liquid container 14. The inflow line is connected via the
11 access opening 2 to a first expansion vessel 1a. The first
12 expansion vessel 1a serves for detecting the gas volume of the
13 unit 12 collecting in the expansion vessel 1a. Via an outlet
14 opening 3, the first expansion vessel 1a is connected by means
15 of a further inflow line 13 to a second expansion vessel 1b,
16 arranged higher, via the access opening 2. Furthermore, the
17 outlet opening 3 is located in the upper covering 10a (not
18 represented) and serves for equalization with the ambient air.
19 The gas volume measured in the second expansion vessel 1b is
20 then measured at ambient pressure.

21

- 1 Designations
- 2
- 3 1a first expansion vessel
- 4 1b second expansion vessel
- 5 2 access opening
- 6 3 outlet opening
- 7 4a upper connecting element
- 8 4b lower connecting element
- 9 5 upper buoyant body
- 10 6 lower buoyant body
- 11 7 fixed-in-place force transducer
- 12 8 gate check
- 13 9 fixed vertical level
- 14 10a upper covering
- 15 10b lower covering
- 16 11 shaft
- 17 12 unit
- 18 13 inflow line
- 19 14 liquid container
- 20